Modification of the Stratification and Velocity Profile within the Straits and Seas of the Indonesian Archipelago

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LONG-TERM GOALS

To understand the circulation and mixing within the Indonesian Seas associated with topographic configuration, monsoonal driven sea-air flux of momentum and buoyancy, and tides.

OBJECTIVES

1. To utilize existing in situ data (XBT/XCTD, CTD, LADCP, mooring time series, tide gauge records) and satellite data (TRMM, SAR, SST, scatterometer, altimeter) to advance the study of the spatial and temporal scales of topographically and tidally linked circulation, sea-air fluxes, and mixing and internal wave phenomenon within the Indonesian Seas.

2. To develop in collaboration with Indonesian marine agencies and universities a study of the regional variability of meso- and sub-mesoscale processes and ocean strait dynamics within the Indonesian Seas, centered upon field observations.

APPROACH

To analyze in situ and satellite data to identify and assess the relevant regional scale, meso-scale and smaller processes within the Indonesian Seas, for the development of a small-scale circulation and mixing study.

WORK COMPLETED

The in situ and satellite data within the Indonesian Seas were analyzed in regard to identifying the regions where the processes controlling the regional scale circulation, mixing, and ocean-atmosphere interactions would be most evident. The geographic region that reveals the most sensitivity to the relevant processes was successfully identified, enabling precise planning of a focused collaborative oceanographic research program. In Indonesia these results were presented as: "Increasing the Impact of Wind-Induced Mixing in the Indonesian seas: Upwelling, ENSO, Mindanao and Halmahera Eddies, and Internal Tides".

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RESULTS

The Seram Sea in the northeastern Indonesian Seas has been identified as the location that is most revealing of the processes that impact the heat and freshwater inventories within the Indonesian Seas, and therefore the linkage by sea-air fluxes to the larger scale climate system.

In the eastern Indonesian Seas the precipitation timeseries (Figure 1a) reveals the large variability that impacts the region annually and interannual. The anomaly of the precipitation timeseries (Figure 1b) reveals the minimum rainfall routinely observed each year during the southeast monsoon, June-July-August, and the association of El Niño years with droughts (1983, 1998) in the region. The Sea Surface Temperatures (SSTs) in the eastern Indonesian Seas, for example in the Seram Sea (Figure 2), reveal the relatively dramatic drop to cold SSTs during the windy southeast monsoon, June-July-August, and the association of the coldest monsoon seasons with El Niño years.

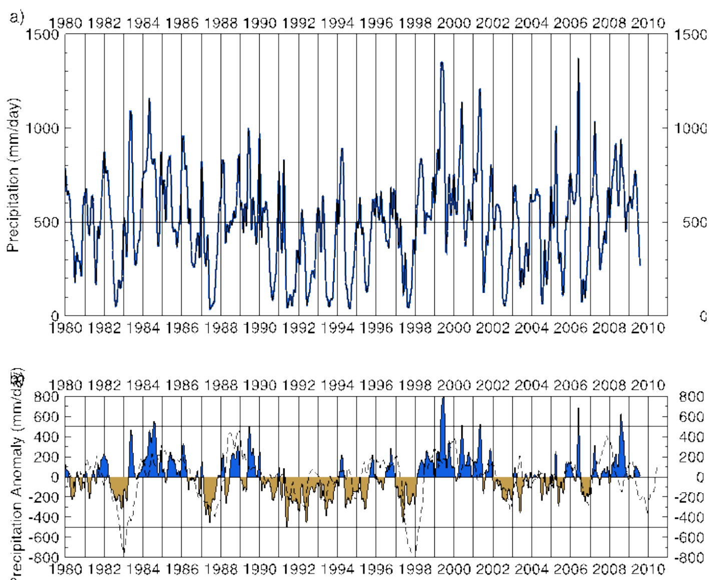

Figure 1. The precipitation timeseries for the the northeastern Indonesian Seas (a) and anomaly (b) revealing minimun rainfall during June-July-August and droughts associated with El Niño years.

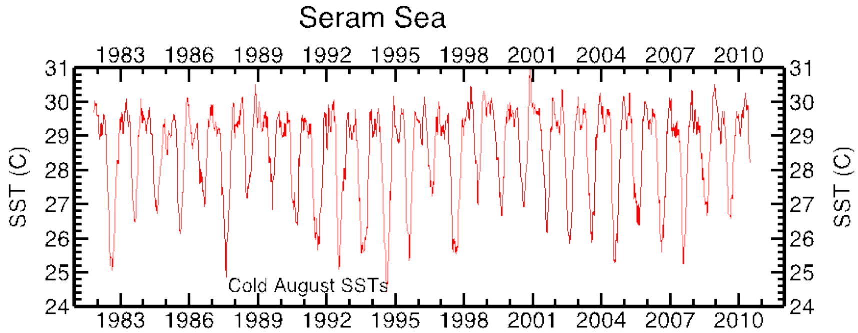

Figure 2. The Seram Sea SST timeseries revealing relatively cold August SSTs with the coldest years associated with El Niño years.

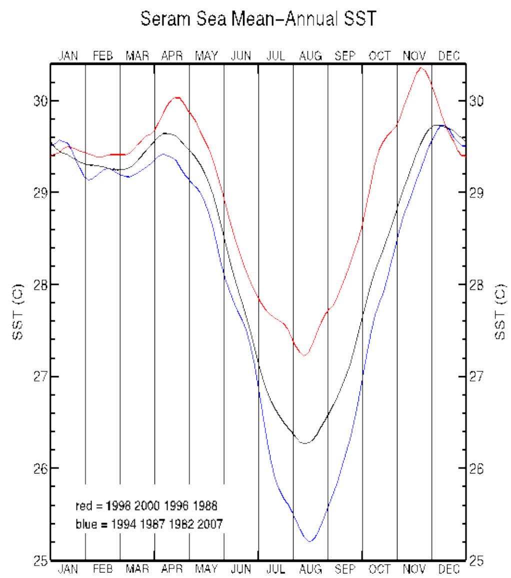

Figure 3. The Seram Sea mean-annual SST with the mean (black curve) and the average of four relatively warm-August years (red curve, 1988, 1996, 1998, 2000) and four relatively cool-August years (blue curve, 1982, 1987, 1994, 2007) revealing a greater then 2.0 Celcius interannual spread as opposed to the less then 0.5 Celsius interannual spread observed in February.

The mean-annual SST in the eastern Indonesian Seas not only reveals the monsoon signal and its association with El Niño years (Figure 3), but also the range in interannual SST response depending on monsoon season: during the southeast monsoon, June-July-August, the interannual SST variability range is larger then 2.0 Celsius, whereas during the northwest monsoon, January-February-March, the interannual variability range is quite small, less the 0.5 Celsius. The map of the Root-Mean-Squares (RMS) of February SSTs throughout the Indonesian Seas (Figure 4a) reveals that the lowest SST RMS values are located in the Seram Sea, with less then 0.35 Celsius RMS, in contrast to those during August when the SST RMS values are largest in the Seram Sea, with values greater then 0.80 Celsius RMS (Figure 4b).

The map of the August average SST for the Indonesian Seas (Figure 5a) shows the overall cool SSTs in the eastern Indonesian Seas observed during August, but the August anomaly SSTs with the 4 coolest Augusts (1994, 1987, 1982, 2007) minus the 4 warmest Augusts (1998, 2000, 1996, 1988) again identifies the Seram Sea region, with larger then 2.0 Celsius anomaly, as the location with the largest signal, and therefore most indicative of the controlling processes (Figure 5b). In addition, when contrasting El Niño versus La Niña years, the ocean temperature profiles in the region reveal the same trends as the SSTs, with little temperature variability observed in February, 1 Celsius or less (Figure 6a) in the Seram Sea region, but with significant temperature variability in August, up to 4 Celsius (Figure 6b) in the eastern Seram Sea region. Therefore variability at both seasonal and interannual timescales is accentuated in the Seram Sea region of the Indonesian Seas distinguishing it as a key indicator location of the processes that impact the heat and freshwater inventories within the Indonesian Seas, and therefore the linkage by sea-air fluxes to the larger scale climate system. A schematic reveals how the varying oceanic conditions that control the depth of the Indonesian thermocline when subjected to the mixing and circulation processes, even if they were non-varying, will result in SST variability in the eastern Indonesian Seas (Figure 7).

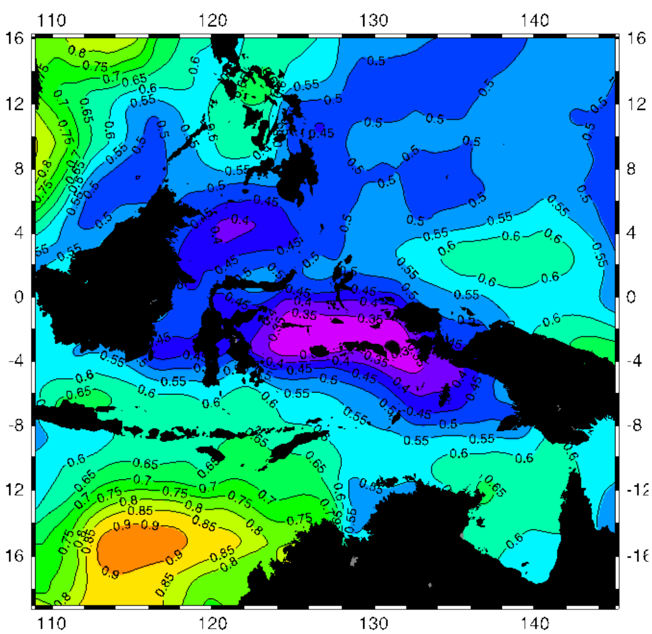

Figure 4a. A map of the Root-Mean-Squares (RMS) of February sea surface temperatures (Celsius) in the Indonesian Seas, calculated from the OI SST dataset. Low RMS, of less then 0.35 Celsius, is revealed in the Seram Sea (magenta region).

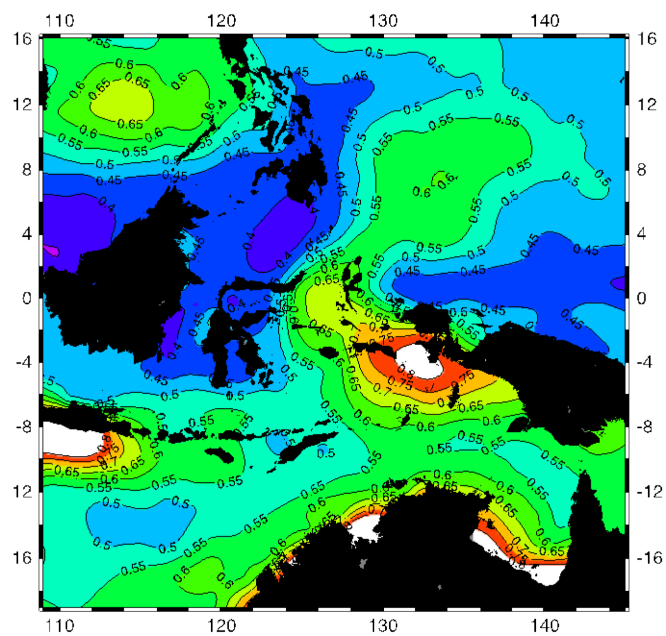

Figure 4b. A map of the Root-Mean-Squares (RMS) of August sea surface temperatures (Celsius) in the Indonesian Seas, calculated from the OI SST dataset. High RMS, greater then 0.80 Celsius, is revealed in the Seram Sea.

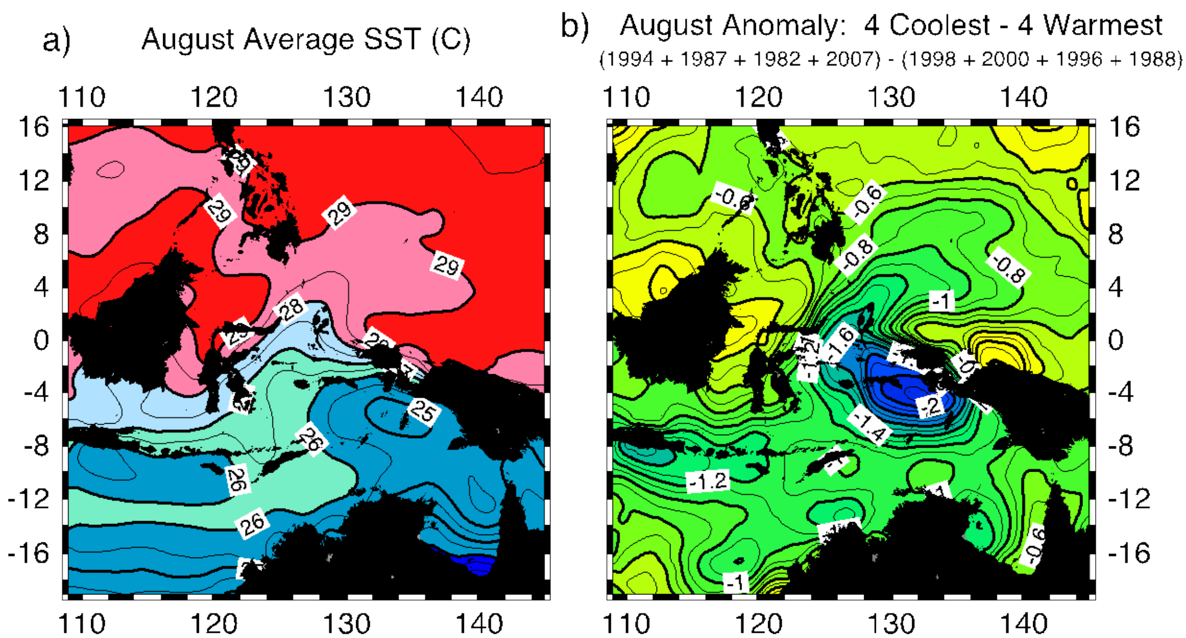

Figure 5. In panel (a) the map of the August average SST (Celsius) for the Indonesian Seas, and in panel (b) the August anomaly SST with the 4 coolest Augusts (1994, 1987, 1982, 2007) minus the 4 warmest Augusts (1998, 2000, 1996, 1988). In panel (b) the largest SST anomaly, larger than 2 Celsius, is revealed in the Seram Sea region.

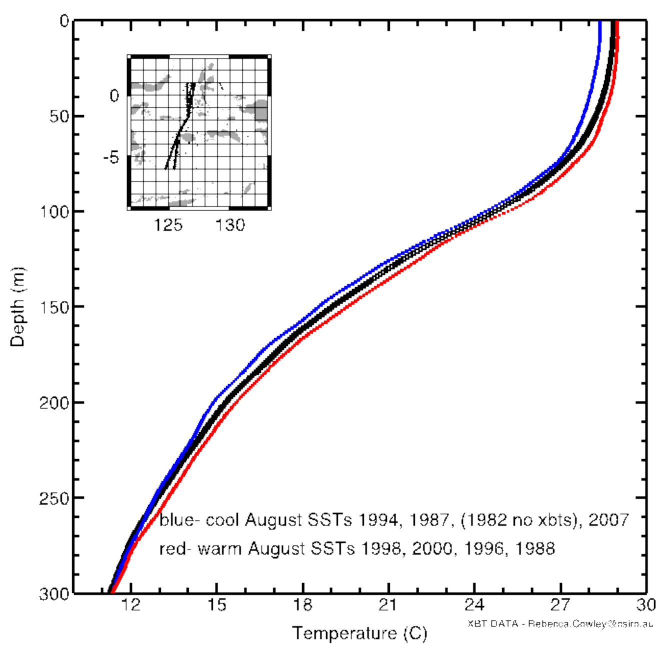

Figure 6a. The February eastern Indonesian seas temperature profiles from XBT data revealing that there is little variability, 1 degree Celsius or less, in the thermocline during February when contrasting El Niño versus La Niña years.

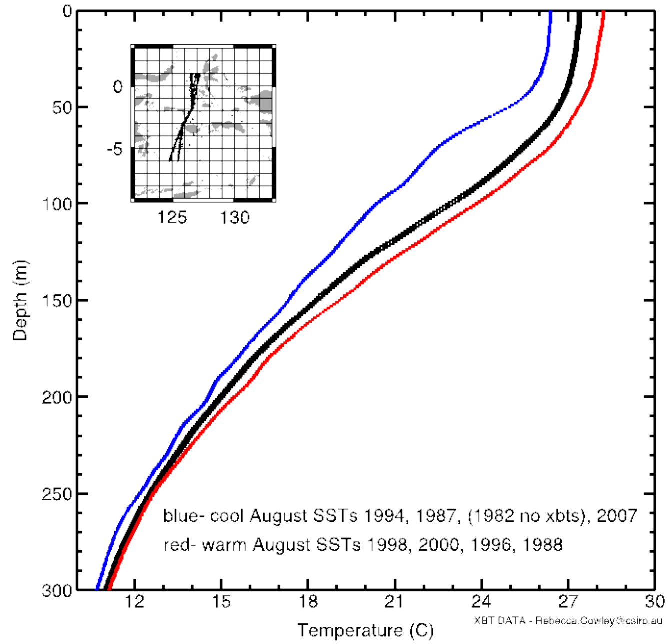

Figure 6b. The August eastern Indonesian seas temperature profiles from XBT data revealing that there is large variability, up to 4 degrees Celsius, in the thermocline during August when contrasting El Niño versus La Niña years.

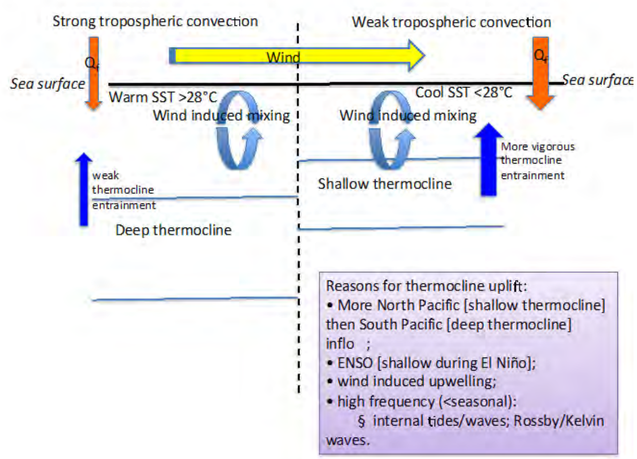

Figure 7. A schematic of the interrelated oceanic conditions and processes controlling the variability in the SST in the eastern Indonesian Seas, and therefore through ocean-atmosphere interaction ultimately impacting the precipitation variability in the region.

IMPACT/APPLICATIONS

The transfer of tropical water from the Pacific to the Indian Ocean through the complex archipelago of the Indonesian Seas, the Indonesian Throughflow [ITF] is considered to be a first order factor impacting the heat and freshwater inventories of those oceans, and as such is linked by sea-air fluxes to the larger scale climate system. Increased understanding of the circulation and mixing within the Indonesian Seas associated with topographic configuration, monsoonal driven sea-air flux of momentum and buoyancy, and tides will enable improved estimates of the factors impacting these inventories.

RELATED PROJECTS

None.